LYONDELL

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November 3, 2000

Certified Mail Receipt #
Fairway Delivery Waybill 100785

Mr. Brian Graves
U. S. Environmental Protection Agency, (6WQ-SG)
1445 Ross Avenue
Dallas, Texas 75202-2733

RE: 2000 HWDIR EXEMPTION PETITION REISSUANCE
LYONDELL CHEMICAL COMPANY, CHANNELVIEW PLANT

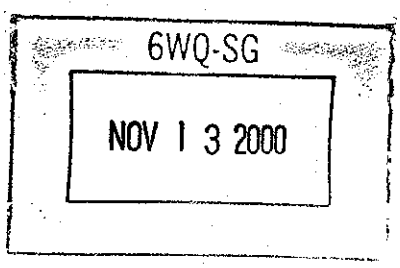
Dear Mr. Graves:

Lyondell Chemical Company (Lyondell) is pleased to submit two copies of this 2000 Hazardous Waste Disposal Injection Restrictions (HWDIR) Exemption Petition Reissuance for our Channelview Plant. This document replaces the 1998 HWDIR Exemption Modification request previously submitted and addresses the September 10, 1998 Notice of Deficiencies specific to that document. Information included in the 2000 HWDIR Exemption Petition Reissuance incorporates and builds upon our 1990 approved petition, and 1992 and 1994 approved reissuances, however, this document is "stand alone" and is anticipated to be complete. Comments from your staff's review are incorporated into the submitted reissuance and we have followed relevant guidance documents issued by EPA to prepare this document. The scope of our request for reissuance fall within the following bounds:

- The Lyondell Channelview Plant is requesting that the exemption be extended from December 31, 2010 to December 31, 2020.

- The Lyondell Channelview Plant is requesting that the well specific injection limits be modified so that it is conditioned to a cumulative injection volume, designated by injection interval (i.e., a "by sand" designation).

- Lyondell Channelview Plant is requesting that EPA Waste Codes F003 (spent acetone solvent), D007 (chromium), D026 (total Cresols), P003 (Acrolein), P047 (4,6-dinitro-o-cresol & salts), U001 (Acetaldehyde), U004 (Acetophenone), U031 (n-Butyl alcohol), U055 (Cumene), U074 (Cis-1,4-dichloro-2-butene), U075 (Dichlorodifluoromethane), U077 (Ethylene dichloride), U140 (Isobutanol), U165 (Napthelene), U188 (Phenol), U213 (Tetrahydrofuran), U226 (1,1,1 trichloromethane), and ~~U213~~ (Xylene) be added to Petition Reissuance Condition No. 5 for protective purposes.. 239



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- Lyondell Channelview Plant is requesting that Petition Approval Condition No. 7 be modified such that only a single annual injection/falloff test be required to characterize the reservoir. Results of our May 2000 interference test show that the two wells are in pressure communication and share a common reservoir.

- Lyondell Channelview Plant is requesting that the current waste stream specific gravity range of 1.00 to 1.09 at 60 °F be reconditioned to a weighted rolling average waste stream density range of 1.019 to 1.100 at 60 °F.

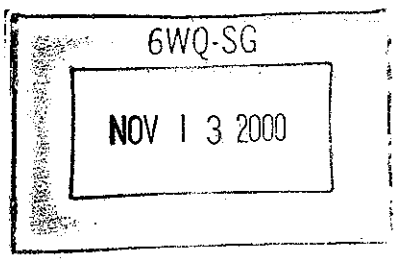
In support of these HWDIR Exemption Petition Reissuance requests, revised modeling is included justifying the modifications. Modeling was prepared utilizing very conservative assumptions in order to overpredict plume extent and pressure buildup. Even under these very conservative scenarios, modeling demonstrates that continued injection into the injection interval sands will, to a reasonable degree of certainty, be protective of human health and the environment for as long as the waste remains hazardous.

We believe the completeness of the submitted information will allow an expedited and detailed review by you and your staff. Please contact Mr. Phil Nangle at (281) 291-2867 if you have any questions, or require additional information.

Sincerely,

Gary L. Koehler
Derivatives and Facilities
Plant Manager

Enclosures



ARCO CHEMICAL COMPANY
Channelview Facility Notice of Deficiencies
September 10 1998

Background

ARCO operates two Class I hazardous waste injection wells (WDW-148 and WDW-162) at its facility located in Channelview, TX. ARCO received an initial exemption from EPA on June 29, 1990. ARCO received approvals for two different petition reissuances requests on March 24, 1992, and April 22, 1994. As part of this 1998 petition reissuance request, ARCO is requesting revisions to the rate allocations, specifically, changing from a monthly volume per well to a maximum monthly volume per injection interval. ARCO is also requesting the addition of waste codes D007, D026, F003, and U213.

NOTICE OF DEFICIENCIES

General

1. Throughout the reissuance document, ARCO should provide a more precise location of information referenced in previous submittals since there are numerous volumes and revisions associated with each petition submittal. ARCO makes several references to the approved 1990 petition document. This reference should be more specific by stating which version of the initial petition that the reference can be found in along with the Volume, Section, and page number.

   Response: Lyondell has provided a more precise location for certain information referenced from the original petition and previous reissuances, however, this 2000 HWDIR Exemption Petition is prepared as a "stand alone" document and we believe that all supporting data is included in this document. Appendices in the revised document include previously submitted supporting information.

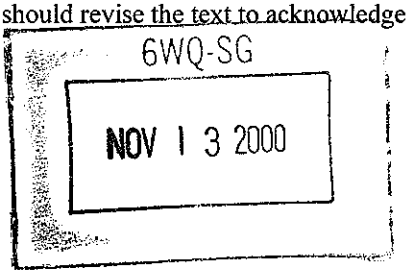
2. Several items were included in Appendix 2-5 and Appendix 2-6 in support of information listed in the text portion of the reissuance document. However, the text did not reference all of the information provided in the appendices. ARCO should confirm that all the support information has been referenced within the section of the document in which it validates.

   Response: Lyondell has reviewed the document and believed that all supporting information provided in the expanded appendices has been referenced in the revised text.

3. In the executive summary, ARCO discusses in some detail the changes requested in the 1998 reissuance concerning rate allocations limited by Petition Approval Condition No. 2. ARCO is also requesting changes to the waste codes listed in Petition Approval Condition No. 5. The waste code revisions are not mentioned in the executive summary, but discussed on page 1-2 of Section 1.1 of this request. The executive summary should include a brief summary of all changes requested in the petition document.

   Response: Waste code additions for protective purposes were referenced in Item 1 on page x of the 1998 HWDIR Exemption Petition Modification Executive Summary. These additions are found on page vii (Item 1.) of the revised document.

4. The waste streams permitted for injection at the Channelview facility are listed on page 1-2 of Section 1.1. One waste stream is olefins waste caustic from Lyondell. Ownership of Lyondell Petrochemical Company has changed to Equistar Chemicals, L.P. ARCO should revise the text to acknowledge this change.



Response: Facility name changes since submission of the 1998 HWDIR Exemption Modification have been incorporated into the 2000 HWDIR Exemption Petition Reissuance, these are as follows:

ARCO Chemical Company is now Lyondell Chemical Company

Lyondell Petrochemical Company is now Equistar Chemicals, L.P.

Merichem Company is now Merisol

In the revised document, care was taken to reference injection wells by their Texas Natural Resource Conservation Commission Permit Number, which has not changed.

5. ARCO provided the composition of their typical well feed in Appendix 1-1. ARCO should also include the latest detailed analysis of their waste stream. The lab analysis should list the wastestream constituent concentrations in mg/l or ppm. The specific gravity and reference temperature of the sample tested should also be listed.

   Response: A detailed analysis of the waste stream is included in Appendix 1-1 of the 2000 HWDIR Exemption Petition Reissuance. Specific Gravity data for a 4-year period referenced at 60 °F is included in Figure 1-8 of this document.

6. The April 22, 1994, approved specific gravity range of 1.00 - 1.09 (petition Condition No. 4) of the no migration exemption is referenced to 60°F. This petition approval condition should be referenced to the temperature used in the analysis of the daily waste samples for easy verification of compliance. ARCO should provide the reference temperature used to analyze the waste samples, and if different, provide the range of specific gravities at this reference temperature.

   Response: The facility reports specific gravity at a reference temperature of 60 °F as detailed in Section 1.8 – Implementation and Compliance of the 2000 HWDIR Exemption Petition Reissuance.

7. In Sections 1.3 and 1.4, ARCO provides well data for each injection well. This section should be expanded to include a discussion of all major workovers conducted in each well, including the 1996 sidetrack of WDW-148. Updated well schematics should also be provided for this section illustrating the current completion of each well.

   Response: Section 1.0 of the 2000 HWDIR Exemption Petition Reissuance has been expanded to include the well workover of Plant Well 1 (WDW-148) which was conducted to provide a permanent enhancement to the operability of that well. No other workovers have been conducted on the two plant wells.

8. ARCO should provide a simple diagram denoting the distances between each ARCO injection well and the distance to offset injection wells.

   Response: Figure 2-2 shows the locations of the Class I injection wells included in the modeling. Distances (in feet) between model wells is included in the model run Summary Output .SUM files included in Section 2.0 appendices.

9. ARCO is requesting additional waste codes and constituents. ARCO must make a compatibility demonstration for these additional waste constituents.

   Response: Waste compatibility to well materials is included in Section 1.0 and waste compatibility to geologic materials is included in Section 4.0 of the 2000 HWDIR Exemption

Petition Reissuance. The requested additional codes are for protective purposes and may result from de minimus losses. Therefore these constituents will be present (if at all) in extremely low concentrations, likely to be non-detect. Therefore, waste compatibility as presented in Sections 1.0 and 4.0 is correct.

Geology

1. ARCO should include a thorough discussion of the geology and how it was incorporated into the modeling strategy in Section 2.2.

   Response: Section 4.0 – Site Geology has been added to the 2000 HWDIR Exemption Petition Reissuance. This section places the site in its regional and local geologic context. Model strategy is discussed in Section 2.5 – Flow and Containment Modeling.

2. ARCO should include a discussion on the dip rate in the geologic parameter discussion in Section 2.2.3. In the 1994 reissuance, ARCO modeled the low density 10,000 year plume utilizing dip rates of 170 ft/mi for 2300 years (6-6 miles) and 30 ft/mi for 7700 years. Review of the Anahuac and Vicksburg structure maps indicates that the 30 ft/mi value may not be the most conservative. ARCO should resubmit the Vicksburg structure map with the composite 10,000 year waste plume overlain for verification of the dip rates. ARCO should evaluate the plume area and include a discussion on why the dip rates are conservative.

   Response: A review of dip rates presented in the approved 1994 HWDIR Exemption Petition in comparison to the Vicksburg Structure Marker Map shows that the 30 feet/mile dip rate may not be the most conservative. The requested structure maps are included in Section 4.0 – Site Geology of the 2000 HWDIR Exemption Petition Reissuance. From the Vicksburg Structure Marker Map, Figure 2-9 has been prepared to show a profile of the geologic structuring and dip rates incorporated into the DuPont 10,000-Year Waste Plume Model FORTRAN Code. The relevant section of the FORTRAN Code is also included in the model simulation run documentation.

3. ARCO provided a type log in the first portion of Appendix 2-5. No reference to this type log is included in the geologic input discussions in Sections 2.2.3 or 2.2.4. The type log submitted does not clearly illustrate the top and base of each injection interval. EPA requests ARCO submit a type log that clearly annotates the injection intervals and injection zone.

   Response: A schematic illustrating the injection intervals and other relevant regulatory definitions using the geophysical well log from Plant Well 2 (WDW-162) is included as Figure 1-3 of the 2000 HWDIR Exemption Petition Reissuance.

4. ARCO states in Section 2.2.4. page 2-6, Volume 1, that the layer thickness model input parameters were determined from the evaluation of geophysical logs and isopach maps. However, the isopachs have insufficient data point values to document the thickness distributions. A small number of artificial penetrations reached the injection interval in the less-dense plume area. Of these, several were not used; and therefore, the submitted isopachs are not complete. ARCO must properly document (particularly in the updip/buoyant plume direction) the net sand thicknesses of each modeled layer. Proper documentation must consist of sufficient point values to properly define net sand thickness.

   Response: The isopach maps submitted in the approved 1994 HWDIR Exemption Petition used all of the wells available at that time. During preparation of the 2000 HWDIR Exemption Petition Reissuance, a log request was made to Cambe in Houston for additional well data. Many of the wells previously unavailable were now available. These wells have been integrated into the revised sand isopach maps, providing better documentation within the plume track area.

5. In discussing injection interval porosity on page 2-10 of Section 2.2.6, Volume 1, ARCO

makes reference to 1996 porosity, well logs and sidewall cores. However, there is no reference to the location of the core information or the porosity well log. EPA requests ARCO clarify its reference or supply the core information and porosity log as part of this reissuance document.

Response: The open-hole log from the sidetrack of Plant Well 1 (WDW-148) is included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance. Sidewall and whole core data collected during the original drilling of the plant wells is also included in this appendix.

6. ARCO states on Section 2.2.1, 1.2, page 2-18, Volume 1. that it obtained its total shale porosity value of 21 percent from Appendix 2-9 of the original 1990 petition. Appendix 2-9 is a discussion of methods used to determine shale porosities in areas of-limited data. Apparently, ARCO has not taken shale core samples from its facility wells to determine a specific porosity value for the confining shales. Following the 1996 sidetrack of WDW- 148, ARCO conducted a Litho-Density Porosity well log survey as additional support to core information in defining the injection interval porosity. Therefore, ARCO should compare its previous shale porosity findings with the findings from the recent porosity tool responses and submit this as additional support for its confining shale porosity value of 21 percent

Response: Aquiclude layer porosities are primarily determined from the correlations developed for Gulf Coast shales (see Appendix 2-6 - Shale Porosity and Permeability) and confirmed with local data. Shale porosity (total bulk volume porosities) are available from the Elf Atochem North America, Inc., Plant Well 2 (WDW-230). Total bulk volume porosity obtained from whole core shale sample in the Anahuac Formation at 4,537 feet is 21.8 percent, which is in good agreement with the values used in the Flow and Containment model.

The Array Induction Imager/Litho-density/Gamma Ray/Caliper log from the sidetrack hole of Plant Well 1 (WDW-148) was reviewed for supporting information on shale porosity. However, the borehole of the sidetrack well is very ratty and uneven. Borehole rugosity has a great effect on the pad tool readings of the Litho-density log. However, good shale in relatively straight hole appears to occur at depths between 6,494 to 6,500 feet and 7,070 to 7,090 feet. The bulk density read by the tool across these two areas is 2.25 to 2.3 gm/cm3. Assuming a formation fluid density of 1.05 gm/cm3 at reservoir conditions (typically a mud filtrate density of 1.0 gm/cm3 is used for porous, permeable intervals, however, since this is shale assume no infiltration and use formation brine) and a matrix density of 2.5 gm/cm3 for illite/smectite clays (Baroid, 1931), the calculated porosity for the 2.25 bulk density reading is 17.24 %. The bulk density value of 2.3 equates to a lower porosity of 13.8 percent. Therefore, the use of 21 percent is conservative.

7. In Section 3.2, page 3-4. Volume 3, ARCO outlines its process for determining corrective action within the AOR. ARCO's statement indicates that all cone of influence/pressure buildup calculations, relative to artificial penetrations within the AOR, were conducted from the top of the current shallowest injection reservoir (i.e., Frio A sand). The shallowest approved injection interval sand, Sand D, is approximately 350 feet shallower than the top of the Frio A sand. Conservative values are used in the no migration demonstrations for each injection interval. The most conservative non-endangerment demonstration may be based upon the D sand or E-F sand due to the depth of the injection interval and pressures caused by injection . ARCO should revise its statement and indicate that its non-endangerment demonstration considered the depth and pressure buildup in the Frio D, E-F, and A approved injection intervals.

Response: Generally, calculation examples presented in the text use the Frio A Sand since it is currently the shallowest injection interval. However, the cone of influence and pressure buildup calculations are sand specific for the Frio D, Frio E&F, Frio A, Frio B, and Frio C Sands. Therefore this statement has been revised to indicate that calculations are sand specific.

8. In Table 3-3, Volume 3, ARCO lists the allowable pressures for potential problem wells. The allowable pressure in the D Sand reported for AP 11 is approximately 250 psi greater than A-P 10, though the wells are located in close proximity and have similar construction. Similar discrepancies exist between APs 8 and 9. ARCO should explain the discrepancy in the allowable pressures listed for these wells. ARCO should also list the equations and provide the parameters values used to calculate the allowable pressures for each well listed in Table 3-3.

   Response: The calculation for allowable pressure buildup for Ap No. 10 uses an overly conservative mud weight of 9.0 lb/gal as per Notice of Deficiency Number 4 from the July 7, 1993 correspondence from EPA concerning the approved 1994 HWDIR Exemption Petition Reissuance even though this well was abandoned with 10.lb/gal mud. As a further degree of conservatism, the borehole width is used in the gel strength calculation, discounting the inner casing string of drill pipe (3 ½ inch pipe). Ap No. 8 was drilled with 11.8 lb/gal. mud prior to setting the 7-inch protection casing that extends through the injection zone, Ap No. 9 was drilled with 9.8 lb/gal mud prior to setting 7 5/8 inch casing that extends through the injection zone. Note that since Ap No. 9 is cemented across the Confining Zone from 4,676 to 4,900 feet, it is properly plugged and is not further evaluated. Calculations employed in the modeling evaluation are included in Section 3.4 of the 2000HWDIR Exemption Petition Reissuance. Parameter values used in the calculation for all evaluated wells are included in Appendix 3-3 of the 2000HWDIR Exemption Petition Reissuance.

9. In discussing the non-endangerment standards in Section 3.4, page 3-8, Volume 3, ARCO outlines the approach it used in determining the gel strength pressure. However, ARCO improperly stated the gel-strength equation on page 3-11, Section 3.4, Volume 3 for abandoned wells with casing across the injection interval. Determining a diameter for the casing-borehole annulus using the denominator "d_b-d_c", would yield a 3 " diameter borehole for a 10" borehole with 7" casing. The correct annulus value is obtained by calculating the annular area and then determining, the equivalent diameter for this area. For example, a well with a 10" borehole and 7" casing, the equivalent diameter for the annular area would be calculated by subtracting the area of the 7" casing from the area of the 10" borehole (78.54 in^2 - 38.48 in^2) resulting in an annular area of 40.06 in^2. The equivalent diameter for this annular area would be 7.14" instead of 3". EPA requests ARCO revise the pressure due to gel strength equation on page 3-11 for a cased hole and recalculate the allowable pressures listed on Table 3-3, for APs with casing in the injection interval within the AOR.

   Response: The referenced equation is from Davis (1986) *Factors effecting the Area of Review for hazardous waste disposal wells.* In consultation with EPA, Lyondell has modified the calculation methodology to consider the outer protection casing diameter in the relevant equation. Using this value results in a more conservative determination of pressure buildup.

10. Following review of the Anahuac and Vicksburg Marker Structure maps (1994 Reissuance, Figures 3 - 1 and 3 –2, Volume III), the 10,000 Year Waste Plume Track map(1994 Reissuance, Figure 2-35, Volume I), and the D sand Gross Isopach Map (1994 Reissuance, Figure 3-6, Volume III), it appears that the shale-out lobes in the D sand may result in a bifurcation of the less-dense waste plume. The bifurcation of the D sand 10,000 year plume would most likely develop two plume branches, one to the west of the facility and the other to the north. There are insufficient data point values included on the D sand isopach to confirm the present shale-out boundary. In the area of the D sand less-dense plume (updip) direction, ARCO must present additional data point values (S/O symbol for no sand) on the D sand isopach to validate the currently depicted shale-out area. ARCO should also provide a structure map that includes an outline of the D Sand shale-out areas and 10,000 year waste plume for the D sand.

    Response: The availability of well logs for recently drilled wells to the west of the facility provide a more accurate depiction of areas of sand absence (shale out) in the Frio D Sand. The revised Frio D Sand isopach is included as Figure 4-18 in the 2000 HWDIR Exemption Petition Reissuance. This figure shows that no "bifurcation" of the plume will occur.

11. In Section 3.2, page 3-5, Volume 3, ARCO states that the original formation pressure gradient for the Frio A sand unit was determined to be 0.436 psi/ft from an A sand pressure of 3035 psi. In calculating the pressure gradient for demonstrating non- endangerment, the top of the interval must be used. The top of the A sand in the ARCO wells is located at a depth of 6880 feet KB. This depth and a pressure value of 3035 psi would equate to a pressure gradient value of 0.441 psi/ft. Apparently, ARCO has taken the 3035 psi value at the A sand mid-point (6960 feet). EPA requests ARCO define the manner in which it determined its original formation pressure gradient value.

    Response: The approved 1990 HWDIR Petition identifies an original pressure of 3061 psig at 7,024 feet, referencing a Milton Cooke 1979 BHP test in Plant Well 2 (WDW-162). Static pressures measured in the facility wells are included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance. The Milton Cooke survey shows a pressure of 2792 psig at a depth of 6,830, which is slightly less than a gradient of 0.436 psi/ft. Using the gradient stops and this pressure, a pressure of 2994.9 psig is calculated at a depth of 6,880 feet, a gradient of 0.4353 psi/ft. Therefore, the 0.436 psi/ft gradient used in Section 3.2 includes a margin of safety since use of this value results in a slightly less allowable pressure that the true value of 0.4353 psi/ft.

12. ARCO has submitted AP records as documentation of the proper plugging of APs within the plume boundary. However, ARCO has not submitted well logs to properly document the vertical position of the lower most IJSDW or confining, layer relative to the injection intervals or injection zone. Cross-sections were found in the initial petition binders; however, revised transport modeling for the 1994 reissuance redefined the plume boundary. Therefore, EPA requests ARCO submit a properly annotated lowermost USDW, injection zone, etc.) cross-section traversing the most. recent plume, and electric well logs for all APs within the plume boundary.

    Response: The east-west cross section in original petition was replaced by a northwest-southeast section that runs from approximately Victor Blanco Field to Cedar Bayou, traversing the depicted 1994 plume track. This section has been modified and extended at its northern end to extend through Alco-Mag Field. Annotated well logs along this section are included in Appendix 4-7. Well logs for wells within the plume track are included with the State Forms records included in the appendices to Section 3.0 – Area of Review.

13. It appears that ARCO has failed to identify one of the APs within the AOR. On the maps submitted with the 1994 petition, the Sinclair Petrochemicals Fee, located approximately 6,000 feet north of the facility, apparently reached the ARCO injection intervals with a total depth of 7100 feet. The coordinates submitted for the Sinclair well log indicate that the location of this AP may be incorrect; and in fact is the Lyondell injection well. EPA requests that ARCO identify this AP as existing in the AOR or as the Lyondell injection well. If it is found that this AP is the Lyondell well, ARCO must correct all base maps.

    Response: The Tobin base maps used for the geology base map shows the original permitted location for the Equistar Chemicals, LP Plant Well 1 (WDW-36). This well was drilled offsite just north of the 2.5-mile radius Area of Review and is shown as WDW-36 on the current geology maps. The Sinclair well has been removed from the basemaps. AIC originally assigned Artificial Penetration Number 5 to the undrilled location. Since this well was never drilled at this location, AP No. 5 is skipped in the 2.5-mile radius Area of Review so that the original numbering scheme is maintained for all of the other artificial penetrations.

14. AOR APs 2 and 4 are not represented on area base maps included with the 1994 petition reissuance. AP 5 is not included on the AP Location Map included in Appendix 3-2, Volume 3 of the 1998 petition reissuance. ARCO must indicate why these APs were omitted from the base maps; and in addition, submit sufficient documentation, relative to the non-endangerment standards, regarding the status of these APs. ARCO must submit electric well logs for AP Nos. 2 and 4. Well logs for these APs were not found in the initial petition or subsequent reissuance binders.

Response: The Tobin base map used for the geology maps did not show these wells. They have been added to the geology maps included in Section 4.0 – Site Geology. Lyondell has included all of the relevant information found on these wells. AP No. 2 is shown on the Texas Railroad Commission maps as a dry hole with a total depth of 1,713 feet and AP No. 4 is shown on the Texas Railroad Commission map and the Harris County map maintained by Cambe as a dry hole drilled to 3,600 feet. These wells are pre-1930, therefore, electric logs are not available for these wells. Since neither well penetrated the Confining Zone, they do not fall under the strict definition of an "Artificial Penetration", however, Lyondell has included all available information on these two wells for completeness.

Modeling

1. The permeability discussion in Section 2.2.5 provides a listing in Table 2-2, page 2-7, of the measured transmissivities for the falloff tests conducted in the ARCO injection wells since 1990. The falloff tests from 1994 through 1997 were included in Appendix 2-5; however, no references to these documents are included in this section. These documents should be referenced in this section. ARCO should also state that the portions of the reports included are incomplete, pressure data and analyses are included, but other information listed in the table of contents of the reports such as RATs and temperature logs have been omitted.

   Response: All of the falloff tests from 1990 to 1998 have been included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance and are referenced in the permeability discussion. Additionally, a note has been added indicating that the included reports are not complete (i.e., logs not included).

2. In Table 2-2, page 2-7, the transmissivity values listed for WDW- 148 are significantly larger in 1996 and 1997 than the transmissivity values calculated for previous years. The permeability discussion included in Section 2.2.5 did not address these increases or the impact of the higher transmissivity values on the 10,000 year plume.

   Response: Lyondell has revised its model strategy for both pressure build-up and plume modeling. For pressure buildup, all of the flow in the Frio A/B/C sands is modeled into a single layer that is assigned a lower bound transmissibility of 240,000 md-ft/cp, resulting in a conservative depiction of pressure buildup and an upper bounbd permeability of 2 darcies for long-term plume transport. Future flow is also modeled independently into proposed injection intervals Frio D Sand and Frio E&F Sand.

3. In the permeability discussion in Section 2.2.5, Volume 1, page 2-9, ARCO begins a discussion concerning analysis of the E-F sand completed in Merichem's Plant Well 1, WDW-147. The following sentence talks about the 1996 injection/falloff test conducted in Plant Well 1, but references ARCO's WDW-148. This same sentence stated that the 1996 test indicated an average permeability of 1-2 d for the Frio D through Frio C sand interval. Merichem's well, WDW-147, is reported as being completed in the Frio E-F sand. ARCO's well, WDW-148., is currently completed into the Frio A, B, and C sands. Therefore it is EPA's understanding that no well is completed in the Frio D, E-F, A, B, and C sands, which is implied by this sentence. ARCO should clarify this sentence and include a copy of the Merichem test referenced.

   Response: The paragraphs dealing with Merisol's well have been revised to specifically discuss testing in the Frio E and F Sands. Relevant portions of several of Merisol's falloff tests have been included in Appendix 2-6 of the 2000 HWDIR Exemption Petition,

4. ARCO should provide verification for the original bottomhole pressures listed in Section 2.2.7, Volume 1, page 2-11, for WDW-148 and WDW-162. In the initial petition, ARCO listed reference [25], which is a 1979 report by Milton Cooke Co., for justification of the initial pressure in WDW-148 and WDW-162 (original petition document revised 9/89, Volume 1, Section 2.4.7, page 2-24). ARCO should include the verification in this reissuance or reference the location of this documentation in a previous submittal.

   Response: All of the historic static surveys and injection falloff tests on Plant Well 1 (WDW-148) and Plant Well 2 (WDW-162) are included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance.

5. ARCO should provide a copy of the page from the published data or correlations to support the sand and shale compressibilities assigned in Section 2.2.8 and listed on Table 2-1, Volume 1, page 2-5.

This data may be from one of any number of petroleum related references applicable to the injection zone.

Response: Relevant portions of referenced literature are included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance.

6. ARCO should summarize the following parameters and any additional parameters, used to obtain reservoir properties, in one table for easy reference: depth temperature, pressure, pressure gradient, and salinity assigned to each injection interval.

Response: Reservoir property parameters are summarized in a single table (Table 2-10) for easy reference of the 2000 HWDIR Exemption Petition Reissuance.

7. In Section 2.2.9. ARCO states that a conservative formation fluid viscosity is 0.52 cp. ARCO should provide a reference depth and temperature and which injection interval the value represents. ARCO should list the viscosity values. used in the demonstration and provide any nomograph or correlations used to obtain the values with the corresponding reference temperatures, pressure, or salinity. The nomograph should be clearly marked so that the specific value determined is easily identified. The viscosity values assigned should be conservative for use in the pressure buildup and lateral plume demonstrations and the constituent free water diffusivity calculations.

Response: Relevant portions of referenced literature are included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance.

8. Also in Section 2.2.9, ARCO reports the density from a recovered fluid sample was measured to be 1.074 g/cm^3. ARCO should provide a reference depth and temperature for this density value and either include or reference the location of documentation to verify the formation fluid density. A 1978 Drilling and Completion report for WDW-148 was referenced in the density discussion in the initial petition document Volume I revised 8/89, page 2-26, but was not submitted. A specific gravity of 1.074 was listed in Table 3-2,page 3-18, Volume II revised 8/89 of the initial petition document, but no reference temperature is reported. or reference to the depth of the formation sampled. ARCO should document the density values used in the demonstration for the Frio D through C sands. Any nomograph or correlation used to obtain the density values should be provided with the corresponding reference temperature or salinity.

Response: Relevant portions of the recovered fluid sample and referenced literature are included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance. The sample was obtained during backflow operations after perforating the Frio A, Frio B, and Frio C Sands in Plant Well 1 (WDW-148).

9. Section 2.2.10.2, Volume 1, page 2-14, lists the formula used to determine the multiplying factor applied in the Basic Plume Model. ARCO should provide or reference the supporting documentation listing the specific values of porosity and permeability input into this equation to obtain the multiplying value listed for each sand.

Response: Relevant portions of the core reports are included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance.

10. In the Free and Effective Water Diffusion Coefficient discussions in Sections 2.2.11.1 and 2.2.11.2 respectively, Volume 1, page 2-18, ARCO should include in the discussion that the values assigned for each constituent are included on Table 2-5, page 2-20. The calculations used to calculate the free water diffusion coefficients should be provided or referenced to a previous petition document.

Response: Relevant portions of the referenced literature are included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance. A calculation example for benzene is added to the text.

11. ARCO should address the following items regarding Table 2-5 on page 2-20 of Volume 1:

    a) The chemical abstract number for each constituent should be added to the table.
    b) Waste Code F007 does not contain Acetone, waste code F003 does list Acetone.
    c) For the given Health Based Limit and Maximum Waste Stream Composition, the concentration reduction factor is incorrectly calculated for Cresol and Phenol.
    d) The Health Based Limit for Cresol, 0.002, is incorrect.
    e) The Health Based Limit and Basis for HBL listed for Phenol is incorrect.
    f) An explanation should be provided to explain why the constituents with no waste codes are included in the table.
    g) EPA Waste Codes F003 and F005 contain several of the constituents listed; however, ARCO did not include these codes for the constituent. ARCO should confirm that the F003 and F005 waste codes have been assigned to all the constituents desired. For example, F003 and F005 maintain benzene but were not listed for the benzene constituent.
    h) The Method Detection Limit reference of 8270 was used as the Basis for HBL for Cresol. Reference to 8270 was omitted in the bottom of the table.

Note: Since ARCO's submission of the petition reissuance, EPA has revised the Health Based Limit Guideline (2/25/98). The only constituents impacted by this revision are Ethylene Oxide (CAS No. 75-21-8) and Tetrahydrofuran (CAS No. 109-99-9). ARCO should updated the Health Based Limit and Basis for HBL for these two constituents to reflect EPA's revised guideline.

Response: Lyondell has revised its Table 2-12, which correspond to the former Table 2-5.

12. In Section .2.2.12 Waste Disposal History, Volume I, page 2-22, ARCO states a 350 gpm injection rate was modeled at the Lyondell and Merichem Facilities. ARCO specifically stated that the 350 gpm modeled for the Lyondell facility was the TNRCC permitted rate. ARCO should submit a copy of the Lyondell permit to verify this statement. ARCO should also provide justification that use of a 350 gpm injection rate is conservative for the Merichem facility.

    Response: State permits for Equistar, Merisol, and Elf Atochem are included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance. Modeling injection into Equistar's WDW-36 well is conservative since all of that waste is commingled with Lyondell's stream. The injection rate at Merisol has been increased to 800 gpm, which is conservative since the two wells are currently completed in separate intervals. Injection from Elf Atochem's wells in Crosby has been added to the model demonstration for completeness, however the effect on model results is minimal.

13. ARCO should provide or reference the location of injection reports verifying the historical injection assigned for all the injection wells utilized in the modeling demonstrations.

    Response: Injection reports for wells included in the modeling are included in Appendix 2-6 of this 2000 HWDIR Exemption Petition Reissuance.

14. In Figures 2-1 to 2-6, ARCO compares the modeled injection pressures to the historical pressures measured in each well. ARCO should clarify if the injection pressures listed in Table 2-7, page 2-24, have been corrected for pressure due to skin. ARCO should also include the location of the modeling input and outputs illustrated in Figures 2-1 to 2-6 referenced in Section 2.3.1.

Response: This reference has been clarified to indicate that flowing pressures are corrected for skin effects. Model input and output for these pressure comparison runs are included in Appendix 2-7.

15. ARCO should provide a graph of modeled shut-in pressures versus historical shut-in pressures measured for both injection wells. The historical pressures included on the graph should also be provided in a tabular format similar to Table 2-7. The fluid levels should also be included, if below ground level, for easier determination of the pressure gradient.

    Response: Lyondell has included graphs (Figures 2-12 and 2-13) of modeled shut-in pressures versus historic measured values (Table 2-23). Model input and output for these pressure comparison runs are included in Appendix 2-7. Static pressure reports for the wells are included in Appendix 2-6 of this 2000 HWDIR Exemption Petition Reissuance. A summary table in that appendix denotes any indicated fluid levels observed during the gradient surveys.

16. The Pressure Buildup and Vertical Permeation Models included in Appendix 2-6 allow the model to allocate the historical injection volumes for each well. These computer allocated rates are used as the input to the Basic Plume Models also included in Appendix 2-6. Since the injection wells are completed in more than one injection interval, ARCO should reference or provide justification for the allocations assigned by the computer or ARCO should inject the total historical volume into each interval to conservatively demonstrate pressure buildup, vertical migration, and the lateral plume movement.

    Response: Lyondell has revised its model strategy for both pressure build-up and plume modeling. For plume modeling, all of the flow was successively allocated to each individual sand (Frio A Sand, Frio B Sand, Frio C Sand, Frio D Sand, and Frio E&F Sand) so that the most conservative plume is depicted for each. For pressure buildup, all of the flow in the Frio A/B/C sands is modeled into a single layer that is assigned a lower bound transmissibility of 240,000 md-ft/cp, resulting in a conservative depiction of pressure buildup. Future flow is also modeled independently into proposed injection intervals Frio D Sand and Frio E&F Sand.

17. Any changes made to the allocation of an injection interval should correspond to a recompletion or be explained within the reissuance document. The historical injection into ARCO's well 1 (WDW-148) in the input job file in Appendix 2-6, Volume 2, begins in 1978 with injection into the Frio A, B, and C sands. In 1983, the injection allocation is changed to only the Frio A and B sands. ARCO should identify and explain any changes in the injection allocations.

    Response: Lyondell has revised its model strategy for both pressure build-up and plume modeling. For plume modeling, all of the flow was successively allocated to each individual sand (Frio A Sand, Frio B Sand, Frio C Sand, Frio D Sand, and Frio E&F Sand) so that the most conservative plume is depicted for each. For pressure buildup, all of the flow in the Frio A/B/C sands is modeled into a single layer that is assigned a lower bound transmissibility of 240,000 md-ft/cp, resulting in a conservative depiction of pressure buildup. Future flow is also modeled independently into proposed injection intervals Frio D Sand and Frio E&F Sand.

18. ARCO included the injection at the Merichem facility into the currently completed Frio E- F sands. ARCO should address the effect, if any, of any future injection at the Merichem facility into the other Frio sands on the pressure buildup and lateral plume movement demonstrations.

    Response: Lyondell has revised its model strategy to include potential flow into the Frio A, Frio B, and/or Frio C Sands at the Merisol facility. Flow is modeled at 800 ~~gpm, conservatively~~ assuming maximum rates in its current well and its unbuilt Well 2.

19. ARCO utilized image wells 1 IL and 1IA to represent the shale-out boundaries in the pressure buildup and vertical permeation modeling for the Frio D; however, no discussion in this reissuance document or reference to a previous document was provided explaining this modeling strategy. In Figures 2-25 and 2-26, ARCO graphically illustrates a solid line in the graph. ARCO should explain in detail how this line represents the current modeling and shale-out areas.

    Specifically the Frio D Gross Sand isopach submitted in the 1994 reissuance, Figure 3-6, Volume 1, illustrated two areas of pinch-out in the D sand with a channel sand existing between them. Figures 2-25 and 2-26 do not indicate any pressures within this channel located between the two pinched-out areas, but indicate one large area of pinch-out. Modeling a no flow boundary in the pressure buildup model would conservatively maximize the pressure buildup in the reservoir; however, the results should be rotated and applied to the areas on the other side of a no flow boundary where the D sand is present. If a no flow boundary is modeled using image wells, ARCO should conduct a model run in which the fault option is used and compare the results. If the image wells in the current modeling strategy represent separate pinched out areas, ARCO may need to include additional image wells so that image wells exist in each pinched-out area to account for injection at both the ARCO and Lyondell facilities. The modeling strategy should explain the location of each image well and justification for the number of image wells input in the model.

    Response: Lyondell has revised its model strategy for both pressure build-up and plume modeling in the Frio D Sand. Revised sand mapping only shows the presence of a southern "potential" no flow boundary, which is modeled using the implicit fault option in the model.

20. The Yearly Modeled Injection for Maximum pressure Buildup Input .Job Files for the Frio D sand included in Appendix 2-6 Volume 2, lists the image well for the ARCO well (1IA) at an x-y location of 4700-7100. The Output .Sum files submitted for these input files located in Appendix 2-6, Volume: 3, list the injection well coordinates at an x-y location of 4700,-710. The output file does not appear to correspond to the input file provided. The modeling submitted to EPA for review must be for the same data input file. ARCO should provide verification to EPA to demonstrate how the pressure and vertical permeation outputs are from the input data file provided.

    Response: Lyondell has revised its model strategy for both pressure build-up and plume modeling in the Frio D Sand. Revised sand mapping only shows the presence of a southern "potential" no flow boundary, which is modeled using the implicit fault option in the model.

    Submitted input/output files were cross checked to ensure that the proper files have been submitted to EPA.

21. ARCO has not provided documentation to support the occurrence of crossflow between the injection intervals. ARCO should revise the pressure buildup and vertical migration computer modeling strategies to prohibit the crossflow between injection intervals. For example, between 1981 and 1992, crossflow occurs between the D and E-F sands in the pressure buildup .Sum file for the Frio D, Appendix 2-6 Volume 3.

    Response: Lyondell has revised its model strategy for both pressure build-up and plume modeling to ensure that no cross-flow occurs in shut-in injection wells.

22. ARCO should expand the graphical output for the D sand in Figures 2-25 and 2-26 to include the Lyondell injection well and image well locations. The location of the ARCO image well should also be included on both figures.

    Response: Lyondell has revised model figures to include the nearby Equistar and Merisol wells and the locations of modeled no flow boundaries implicitly used in the model.

23. ARCO should update the search for pressure sinks and sources which may impact the no migration demonstrations. All sources should be identified and addressed in the demonstration. ARCO has accounted for offset injection from Lyondell and Merichem in this reissuance.

    Response: Lyondell has added Table 4-5 which lists nearby oil and gas fields and their producing formations. Offset injection wells at Equistar, Merisol, and Elf Atochem are considered in the model.

24. The pressure buildup plots for the Frio D sand were illustrated in Figures 2-25 and 2-26. The same pressures were provided in Figures 3-17 and 3-18. Figure 2-25 and Figure 3-17 were not plotted using the same pressure contour value and cannot be directly compared. Figure 2-26 and Figure3-18 are plotted using the same pressure contour intervals but are not identical. ARCO should explain the discrepancy between the figures: Figures 2-25 and 3-17 should be redrawn using the same value for the contour interval. Additional labels should be provided on the contour interval on the figures for easier identification of the pressure isopleths illustrated.

    Response: Lyondell has reviewed common figures presented in Section 2.0 and 3.0 to ensure that the same isopleth plots are used. Additional contour labels have been added where appropriate.

25. The injection rate schedule in Basic Plume Model for WDW –162 for the Frio A, B, and C sands does not use a constant 700 gpm for the first several years of projected injection. The Frio A and B rate schedules are different than the Frio C rate schedule. ARCO should provide further discussion for the rate schedules used in the basic plume model.

    Response: Lyondell has revised its model strategy for both pressure build-up and plume modeling. For plume modeling, all of the flow was successively allocated to each individual sand (Frio A Sand, Frio B Sand, Frio C Sand, Frio D Sand, and Frio E&F Sand) so that the most conservative plume is depicted for each. For pressure buildup, all of the flow in the Frio A/B/C sands is modeled into a single layer that is assigned a lower bound transmissibility of 240,000 md-ft/cp, resulting in a conservative depiction of pressure buildup. Future flow is also modeled independently into proposed injection intervals Frio D Sand and Frio E&F Sand.

26. ARCO should reference that the values for the free water diffusion coefficients and effective diffusion coefficients (Sections 2.2.11.1 and 2.2.11.2 respectively) are included in Table 2-5. ARCO should also reference or provide the equations used to determine the free water diffusion coefficients listed in Section 2.2.11.1.

    Response: Relevant portions of the referenced literature are included in Appendix 2-6 of the 2000 HWDIR Exemption Petition Reissuance. A calculation example for benzene is added to the text.

27. Maximum upward permeation into the confining layer above the Frio D in the approved 1994 reissuance is stated as 15.12 ft (Section 2.4.2.2,Volume 1, page 2-21) with a maximum pressure buildup of 315 psi (Section 2.4.2.3, Table 2-2, Volume 1, page 2-22). The maximum pressure buildup predicted for the D Sand in the ARCO injection wells was 429 psi (Section 2.4.1.3, Table 2-8, Volume 1, page 2-27); however, the maximum vertical permeation modeled was 14.98 ft (Section 2.4.1.2, Volume 1, page 2-26). ARCO should explain how a larger pressure buildup could result in less vertical permeation.

    Response: The 14.98 foot value is correct in the 1998 HWDIR Exemption Petition Modification. The value in the text of the approved 1994 HWDIR Exemption Petition Reissuance is greater that that shown in the referenced model appendices for that job run, ~~the text value should be~~ lower. Lyondell has revised its model strategy for both pressure build-up and vertical

permeation. The revised modeling is discussed in Section 2.7.1.2 of the 2000 HWDIR Exemption Petition Reissuance.

28. ARCO indicates in this reissuance request, that at the end of the operational period, the D sand maximum reservoir pressure buildup within the AOR boundary will range from 82-170 psi (see Table 2-8,page 2.27, Volume1). However, Figures 2-25 and 2-26 indicate a maximum pressure buildup of 210 psi due to the influence of Lyondell injection. ARCO included Lyondell's injection pressure influence in determining the E-F sand maximum pressure buildup value. ARCO should revise its D sand maximum pressure buildup findings to include the pressure influence from injection at the Lyondell facility.

Response: Lyondell has revised its model strategy for pressure build-up in this 2000 HWDIR Exemption Petition Reissuance. Correct pressures are shown in Table 2-25.

Note: Most of the monitoring wells in the pressure buildup model correspond to locations of artificial penetrations. Monitoring well 1A does not correspond to any artificial penetration and the rationale for its location is unclear.

Response: Monitor point A1 is an arbitrary point located on the Area of Review radius.

The Lyondell well was incorrectly labeled as WDW-32 instead of WDW-36 on some of the base maps previously submitted. ARCO should ensure that the injection wells are correctly labeled on any maps submitted with the 1998 reissuance.

Response: Lyondell has revised its geology maps correcting this discrepancy.